Indian Forester, 141 (10) : 1056-1066, 2015
http://www.indianforester.co.in
ISSN No. 0019-4816 (Print)
ISSN No. 2321-094X (Online)

THE STATE OF *MYRISTICA* SWAMP FORESTS IN SOUTHERN WESTERN GHATS, INDIA - BUTTERFLY SPECIES RICHNESS AS AN INDICATOR

JOYCE JOSE, T.J. ROBY , K.K. RAMACHANDRAN[1] AND P.V. NAIR [1]

Department of Zoology, St. Thomas' College, Thrissur-1, Kerala, India
Email: joyceofthejungle@gmail.com

ABSTRACT

Species richness of butterflies in and around the highly fragmented, threatened and restricted patches of *Myristica* swamp forests in South Western Ghats, Kerala, India was documented. Eighty species of butterflies belonging to 5 families were recorded from these swamp forests with a land area of less than 1.5 km^2 (149.75 ha). Species composition inside and outside the swamps showed above 80% similarity. Presence-absence of butterfly species was affected by variations in host plant diversity, % of canopy cover, % of inundated area and % of ground litter cover. Habitat usage studies indicated that while habitat specialists were restricted to larger patches of evergreen forests, habitat generalists were not similarly constrained and formed the bulk of the species. The ecotone area between the swamps and the adjacent matrix had relatively more number of species, except where the ecotone had been disturbed. The increase in the butterfly species diversity at the expense of habitat specialists and the proliferation of generalists is an indicator of cryptic changes in the swamp environment leading to increase in microhabitats and host plants associated with disturbance and call for immediate conservation measures.

Key words: Butterfly, *Myristica* swamp forests, Species richness, Habitat, Conservation.

Introduction

Small isolated forest remnants are generally accorded low conservation status and given little protection, with the result that they often disappear over time because of continued anthropogenic disturbance. Despite having lower species richness, these rain forest remnants make a substantial contribution to regional diversity (Benedick *et al.*, 2006). But areas protected as nature reserves had lost as many species as unprotected areas had, indicating both the importance of proper management of nature reserves and that nature reserves alone may not be enough to inhibit regional extinction of butterfly (Ockingera *et al.*, 2006) or other species.

Myristica swamp forests were first described by Krishnamoorthy (1960) and classified by Champion and Seth (1968) in the sub-group of tropical fresh water forests (4c/FS1). These freshwater swamp forests are highly fragmented and restricted in distribution due to systematic destruction (Rodgers and Panwar, 1988 a, b) and special abiotic conditions (Chandran and Mesta, 2005; Varghese, 1992) required for their survival. *Myristica* swamps in India have been reported only in the Western Ghats from southern Kerala (Krishnamoorthy, 1960; Varghese, 1992; Varghese and Kumar, 1997; Varghese and Menon, 1999; Nair *et al.*, 2007; Roby, 2011; Roby *et al.,* 2014 a, b), Uttara Kannada in Karnataka (Chandran and Mesta, 2005; Chandran *et al.,* 1999) and Satari in Goa (Santhakumaran *et al.,* 1995). These swamps have many endemics in spite of limited distribution (Ramesh and Pascal, 1997; Pascal, 1998). The *Myristica* swamps in Kerala constitute less than 1.5 km^2 (149.75 ha) which is 0.01% of the State's total land area (Roby *et al.,* 2014 a). Since *Myristica* swamps were not reported prior to the 1960s there is no record of the swamps that perished during logging operations, the Grow More Food Campaign of 1950s and due to associated microclimatic changes (Joyce *et al.,* 2014).

The combined result of natural and anthropogenic fragmentation leaves the surviving species in such habitat remnants confronted with a modified environment of reduced area, increased isolation and novel ecological boundaries (Ewers and Didham, 2005).

The conservation of biodiversity has gained prominence in ecological research during the last few decades. Conservation actions require a measure of biodiversity such as species richness, but its assessment is difficult and therefore the search for surrogates (i.e. indicators) of biodiversity has emerged as an active research topic (Rossi and Halder, 2010). Butterflies are sensitive biota, which get severely affected by environmental variations and changes in forest structure (Pollard, 1991). They respond to disturbances and

> The increase in the butterfly species diversity due to proliferation of generalists is an indicator of cryptic changes in the *Myristica* swamp environment such as increased microhabitats and host plants which are associated with disturbance.

[1]Kerala Forest Research Institute. Peechi, Thrissur, Kerala, India.

changes in the quality of habitat and are thus considered as good ecological indicator species to evaluate changes in the habitat and landscape structure variations (Kocher and Williams, 2000; Kremen, 1992).

In present article author's have analysed the potential of butterfly species' presence and their response to selected ecological data as an ecological indicator and therefore as an endorsement for immediate conservation efforts of the *Myristica* swamps in Southern Kerala.

Material and Methods

Sampling was done in the *Myristica* swamp forest patches of Anchal and Kulathupuzha Forest Ranges and Shendureney Wildlife Sanctuary (8.75^{0} to 9.0^{0} N and 76.75^{0} to 77.25^{0} E) (Fig. 1a, b) from 2004 November to 2007 February. Due to the geophysical characteristics of the swamp forests it was not possible to lay transects or demarcate quadrates for the highly mobile butterflies. Therefore 'fixed radius point count' (Petit *et al*., 1995) was selected as method of sampling. Each swamp was broadly divided into sampling zones of approximately equal radius, namely open zone, periphery zone, intermediate zone and centre zone by paint-marking trees. Four fixed locations were selected in each zone from where time constrained- visual survey was done for every month during sampling period. Butterflies were identified on wing. All the butterflies sighted in the study area were photographed (JVC Handycam and Canon EOS300 digital camera) and the photographs were referred to experts for confirmation of their identification. Specimens at KFRI entomology collections were also studied. Collection of voucher specimens was kept minimal in interests of conservation.

For each butterfly sighting, the time, date, location, swamp name, zone and habitat variables such as temperature, relative humidity, canopy cover, ground litter cover, area under inundation (Joyce *et al.,* 2007) and presence of host plants (Roby, 2011, Roby *et al.,* 2014b) were recorded. Rainfall was not selected as a variable because the amount of rainfall was more or less same for different locations in the study area and it was not practically possible to measure the rainfall received by each swamp.

The butterfly species were divided into four classes on the basis of their status as a habitat specialist or generalist by referring to published work (Gunathilagaraj *et al.,*1998; Kunte, 2000; Palot *et al.,* 2003, 2012; Kehimkar, 2008) and by comparing these results with our observations in field.

1. Class “a”- Wet evergreen forest specialist butterflies which were restricted to unfragmented/ large fragments of evergreen forests.
2. Class “b”- Forest specialist butterflies considered to favour natural healthy forests but which were also observed in degraded and non degraded forests and other areas.
3. Class “c”- Habitat generalist butterfly species (found to visit forests, scrubs, grasslands and homesteads near the forests).
4. Class “d”- Butterflies species, on whose habitat utilisation, data was found deficient or where our observations did not match with published material. Class “d” and unidentified butterflies were not included in nMDS or SIMPER analysis.

Species turnover between the swamp patches and adjacent forests were measured using Jaccard measure (Jaccard index $C_j = j/(a + b - j)$, where, *j* is the number of species recorded in both sites, *a* is the number of species

Fig. 1a : Study area

Fig. 1b : View of a *Myristica* swamp

recorded in Site A and *b* is the number of species recorded in Site B. The butterfly species composition in the four sampling zones (open zone, periphery zone, intermediate zone and centre zone) were recorded and the similarities of the species composition in each zone was analysed using non metric multidimensional scaling (nMDS) in XLSTAT 2010. The similarity/dissimilarity matrix was computed using Jaccard similarity. It was graphically plotted in four dimensions using XLSTAT-3DPlot.

SIMPER (Similarity Percentage) using PAST Ver. 2.17 was used to determine which class (a, b and c) of butterfly were primarily responsible for differences between species composition in different sampling zones. The Bray-Curtis similarity measure implicit to SIMPER was used in the comparison (pair-wise) of two groups.

Results and Discussion

The butterflies recorded during the study were found to visit both swamp and non-swamp areas, *i.e*. no species were found to be specific to the swamp. Eighty species of butterflies (72 identified species), from 57 identified genera and 5 families were recorded from the swamps (Table 1). Fourteen species are protected under the Wildlife Protection Act, 1972 of India.

This is about 25 % of the 316 butterflies found in Kerala state (Palot *et al.,* 2012). The species richness showed variation over the months with the least numbers being observed during the wet months of June, July and August (Fig. 2). The most dominant family was Nymphalidae with 28 genera and 34 species followed by Papilionidae (12 species and four genera) (Fig. 3).

Species turnover

Eighty-five identified species were recorded from outside the swamps as against seventy-two species identified out of eighty from inside the swamps. There was not much difference in the species composition found inside and outside swamp. The Jaccard similarity measure was 0.8131 which means that the species composition inside and outside the swamps were 81.31% similar. The species composition of the four sampling zones showed variations and the dissimilarities have been represented in Table 2.

The *open zone* and *periphery zone* showed the least distance in terms of butterfly species composition. The species composition of the *intermediate zone* does not lie close to the *centre* or the *periphery –open* group but is most similar to that of the *periphery zone (Fig. 4)*. The Shepard diagram for a four dimensional nMDS is shown in Fig. 5 where the abscissa are the observed dissimilarities, and the ordinates, the distance on the configuration generated by the MDS. The disparities are also displayed. Since the points are not spread and are on the same line the MDS map (Fig. 4) is reliable. "Stress" is close to zero at 0.003, which indicates that the test is robust.

The number of butterfly species increased with the number of host plants present (R=0.987, significance level alpha=0.05), temperature and litter cover and decrease in humidity, canopy cover and area under inundation (Fig. 6a-g).

The highest species richness was in the *periphery zone* followed by the *open sampling zone* outside the swamps. The third highest values for richness were recorded from the *intermediate zone*. The least richness was recorded from the *centre* zone. When species richness in the three administrative divisions (Anchal and Kulathupuzha Forest range and Shendurney WLS) was

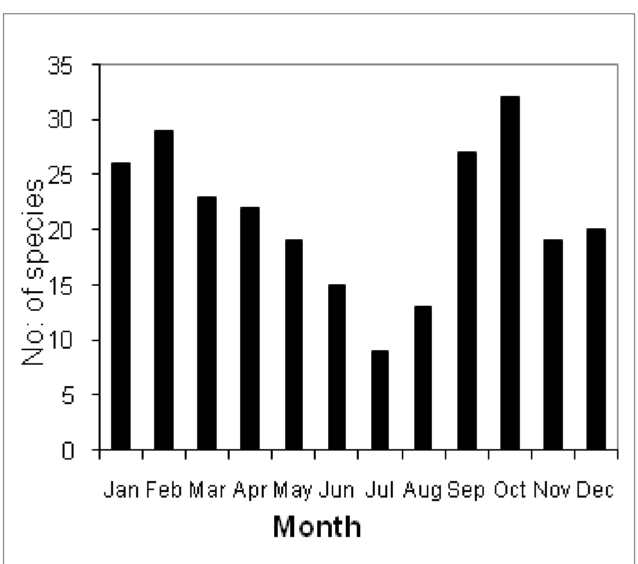

Fig. 2 : No. of species recorded across months

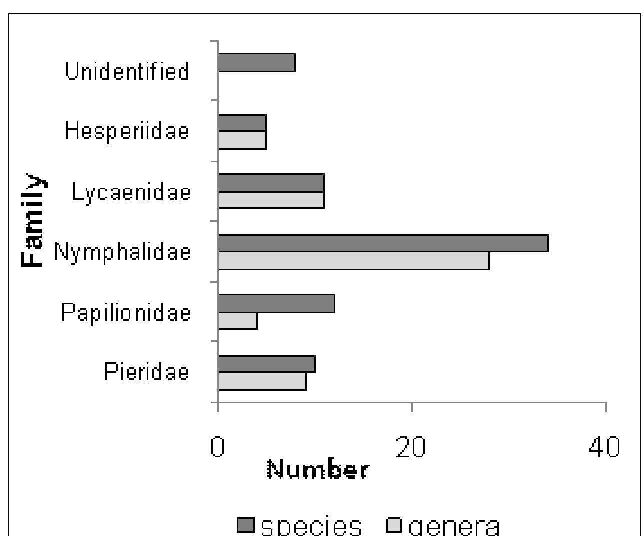

Fig. 3 : Diversity within families

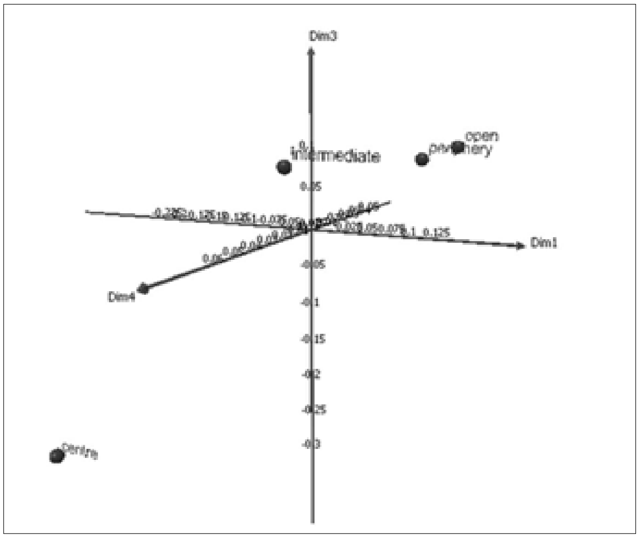

Fig. 4 : A MDS map indicating the similarity/dissimilarity in species composition in the four sampling zones- open, periphery, intermediate and centre

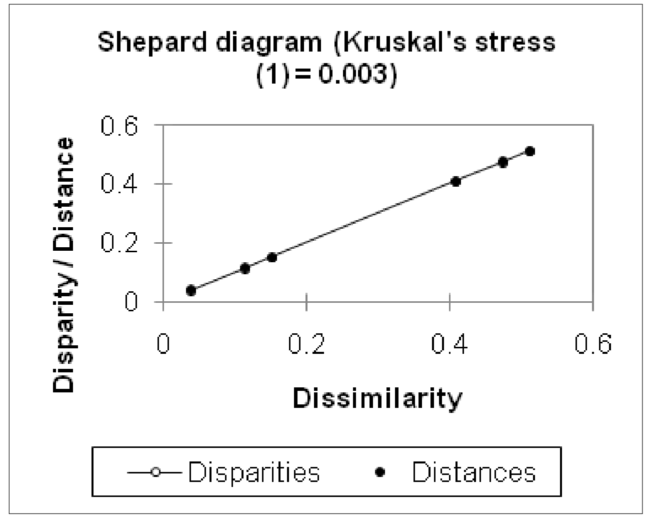

Fig. 5 : Shepard diagram for 4 dimensional representation of MDS

compared, Shendurney had the highest species richness in the *centre* and *intermediate* zones and Anchal had the lowest. However, in the periphery and open zones Shendurney had the lowest species richness (Fig. 6).

The relative humidity, the area under inundation and canopy cover increased and temperature decreased when moving from outside (open zone) the swamp to the centre. Ground litter cover and number of host plants (herbs, shrubs, non-swampy species) were highest in the periphery zone of the swamp and were least in the *centre zone* of the swamp. There was a marked decrease in the litter cover and host plant diversity (Fig. 6) in the periphery zone in Shendurney when compared to the other two ranges (due to fire-lines taken along the edge of the swamp and thus effectively removing the ecotone). There was also a decrease in the number of butterfly species recorded from the periphery zone in Shendurney when compared to Anchal and Kulathupuzha, though the opposite was true in all other sampling zones.

Habitat utilisation by different butterfly classes in different sampling zones:

Only three species, namely *Graphium antiphates* (Cramer), *Idea malabarica* (Moore,) and *Parthenos sylvia* (Cramer) were “a” class butterflies. Within the sampling zones demarcated in and around the swamp forests class “a” butterflies were observed from only those swamps which were surrounded by evergreen forests. Class “a” butterflies were not sighted even once in Anchal range which is comparatively drier and has more degraded forests. In Kulathupuzha, these butterflies were confined to the Poovanthu Moodu – Munnam Chal areas and Choondipara- Appupankutty areas (Roby *et al.,* 2014 a) where the *Myristica* swamps are surrounded by almost undisturbed evergreen forests. These butterflies were also sighted in the Shendurney WLS part of the study area where the swamp forest canopy was almost contiguous with the rest of the evergreen and semi evergreen forests.

Twenty-six butterflies were placed in class “b” and 36 in class “c” (Table 1). These butterflies were recorded from all the three ranges but class “b” butterflies were more common in Kulathupuzha and Shendurney. Class “b” butterflies were dominant especially in the intermediate and periphery areas of the swamps though they did not exclude the centre of the swamp or the surroundings of the swamp. Class “c” butterflies were found in all the zones though they were less common in the centre of the swamp.

SIMPER analysis indicates that maximum overall dissimilarity was contributed by pairing Classes “a” and “c” followed by Classes “a” and “b”. Least dissimilarity was obtained by pairing Classes “b” and “c”. This holds good for the *open zone* also (Table 3 and Fig. 7).

In the periphery zone, the dissimilarity is zero due to the complete absence of Class “a” butterflies and the complete intermingling of Classes “b” and “c” butterflies. In swamps with an evergreen forest surrounding it, there was complete intermingling of Classes “a” and “b” butterflies and in forests surrounded by other matrix Class “a” butterflies were almost nil. Hence, there seem to be no contribution to dissimilarities when Classes “a” and “b” are paired.

The presence of few “a” Class butterflies in the intermediate zone and many “c” Class butterflies led to dissimilarities above 1.5. Dissimilarity was also noted when Classes “b” and “c” butterflies were paired in the *intermediate zone* (1.45).

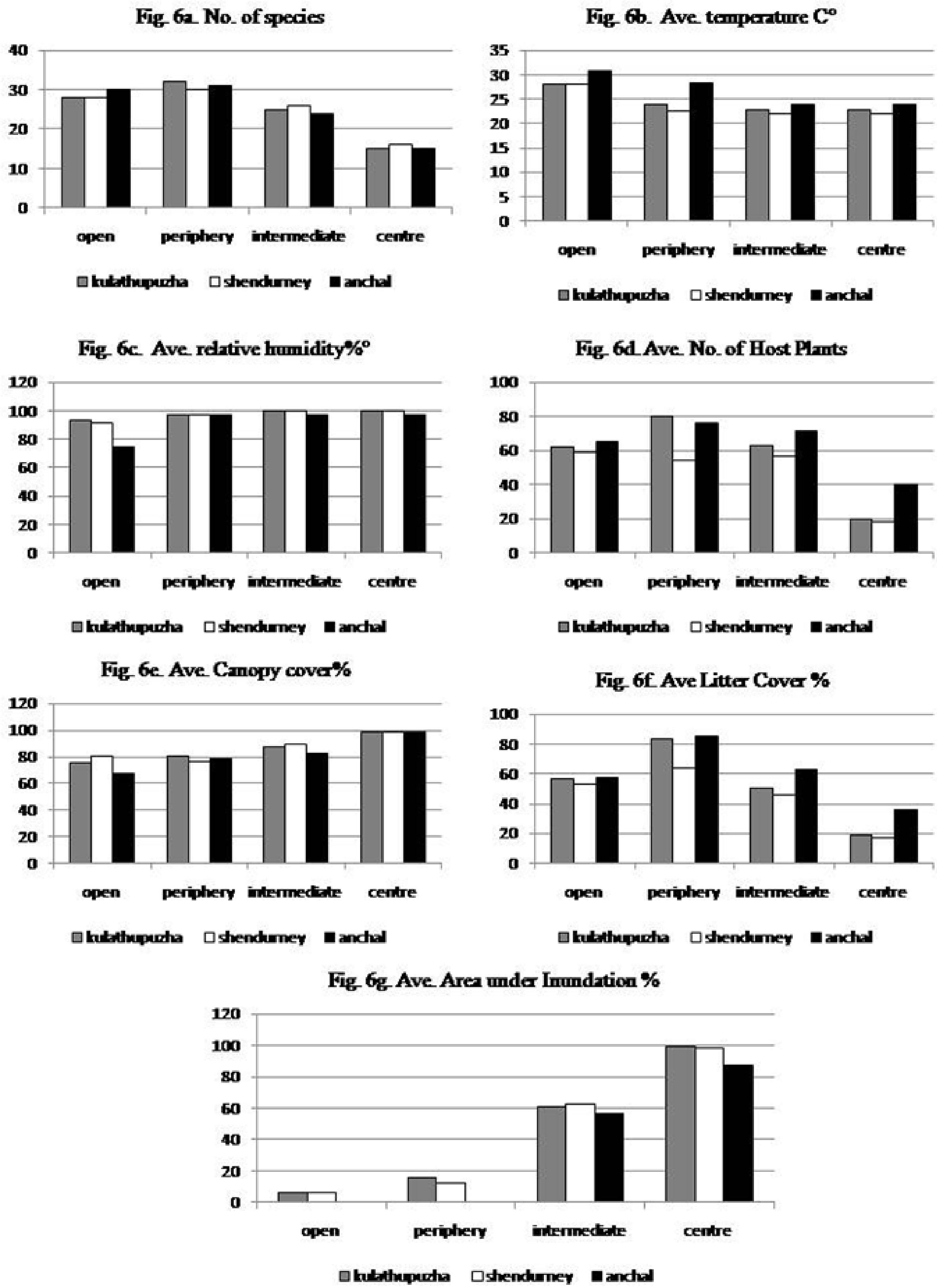

Fig. 6a-g : Graphical representation of differences in No. of species, Average temperature C°, Average humidity %, No. of host plants, Average Canopy (%), Average litter cover (%) and Average Inundated area (%) from different sampling zones (open, periphery, intermediate, centre) in and around the *Myristica* Swamps in Anchal, Kulathupuzha and Shendurney.

Table 1 : Checklist of the Butterflies of *Myristica* Swamps with data on endemicity, protection status and habitat specialization

No	Family	Species	Endemic to Western Ghats	Protection Status	@Habitat Specialization Class
1.	Hesperiidae	*Ampittia dioscorides* (Fabricius)			c
2.		*Sancus fuligo* (Mabille)			d
3.		*Telicota ancilla* (Herrich-Schäffer)			c
4.		*Iambrix salsala* (Moore)			d
5.		*Tagiades gana* (Moore)			c
6.		1 unidentified			
7.		2 unidentified			
8.		3 unidentified			
9.		4 unidentified			
10.		5 unidentified			
11.		6 unidentified			
12.		7 unidentified			
13.	Lycaenidae	*Caleta caleta* (Hewitson)			b
14.		*Discolampa ethion* (Westwood)			b
15.		*Jamides celeno* (Cramer)			c
16.		*Acytolepis puspa* (Horsfield)			b
17.		*Castalius rosimon* (Fabricius)			c
18.		*Euchrysops cnejus* (Fabricius)			c
19.		*Zizula hylax* (Fabricius)			c
20.		*Zeltus amasa* (Hewitson)			b
21.		*Curetis thetis* (Drury)			b
22.		*Thaduka multicaudata (*Moore)		+	d
23.		1 unidentified			
24.	Nymphalidae	*Tirumala limniace (*Cramer)			c
25.		*Tirumala septentrionis* (Butler, 1874)			c
26.		*Parantica aglea* (Stoll, 1782)			c
27.		*Danaus genutia* (Cramer 1779)			b
28.		*Danaus chrysippus* (Linnaeus)			c
29.		*Euploea core* (Cramer)			c
30.		*Idea malabarica (*Moore)	*	+	a
31.		*Athyma ranga* Moore		+	b
32.		*Neptis jumbah* Moore		+	b
33.		*Parthenos sylvia* (Cramer)		+	a
34.		*Pantoporia hordonia* (Stoll)			d
35.		*Tanaecia lepidea* (Butler)		+	b
36.		*Euthalia aconthea* (Cramer)		+	c
37.		*Ariadne merione* (Cramer)			c
38.		*Discophora lepida* (Moore)	**	+	b
39.		*Cyrestis thyodamas* Boisduval			b
40.		*Junonia iphita* (Cramer)			b
41.		*Junonia atlites* (Linnaeus)			b
42.		*Junonia orithiya* (Linnaeus)			d
43.		*Junonia hierta* (Fabricius)			c
44.		*Kaniska canace* (Linnaeus)			b
45.		*Kallima horsfieldi* Kollar		+	b
46.		*Hypolimnas misippus* (Linnaeus)		+	c
47.		*Hypolimnas bolina* (Linnaeus)		+	b
48.		*Mycalesis perseus* (Fabricius)			b
49.		*Melanitis leda* (Linnaeus)			c
50.		*Ypthima baldus* (Fabricius)			c
51.		*Ypthima huebneri* Kirby			c
52.		*Elymnias hypermnestra* (Linnaeus)			c
53.		*Cupha erymanthis* (Drury)			b
54.		*Cethosia nietneri* C.& R. Felder	**		b

55.		*Cirrochroa thias* (Fabricius)	**		b
56.		*Polyura athamas* (Drury)			c
57.		*Charaxes bernardus* (Fabricius)			b
58.		*Libythea cf lepita* (Moore)			d
59.	Papilionidae	*Papilio polymnestor* (Cramer)			b
60.		*Papilio polytes* (Linnaeus)			c
61.		*Papilio dravidarum* (Wood-Mason)	*		d
62.		*Papilio paris* (Linnaeus)			b
63.		*Papilio helenus* Linnaeus			b
64.		*Atrophaneura aristolochiae* (Fabricus)			c
65.		*Atrophaneura hector* (Linnaeus)		+	c
66.		*Graphium sarpedon* (Linnaeus)			c
67.		*Graphium doson* (C. & R. Felder)			c
68.		*Graphium antiphates* (Cramer)			a
69.		*Graphium agamemnon* (Linnaeus)			c
70.		*Troides minos* (Cramer)	*		c
71.	Pieridae	*Appias albina* (Boisduval)		+	c
72.		*Delias eucharis* (Drury)			c
73.		*Pareronia valeria* (Cramer)		+	c
74.		*Hebomoia glaucippe* (Linnaeus)			b
75.		*Leptosia nina* (Fabricius)			c
76.		*Colotis eucharis* (Fabricius)			c
77.		*Ixias pyrene* (Linnaeus)			b
78.		*Catopsilia pomona* (Fabricius)			c
79.		*Catopsilia pyranthe* (Linnaeus)			c
80.		*Eurema hecabe* (Linnaeus)			c

*Species endemic to Western Ghats, ** Endemic to Western Ghats and Sri Lanka
+ Species included in Wildlife Protection Act, 1972
@Habitat specialization class- A, B, C, D-see text for explanation

Table 2 : Distances measured in the 4-dimensional representation space (nMDS)

Zone	Centre	Intermediate	Periphery	Open
Centre	0	0.408	0.476	0.512
Intermediate	0.408	0	0.113	0.149
Periphery	0.476	0.113	0	0.039
Open	0.512	0.149	0.039	0

In the centre zone pairing of "a" and "b" Classes produced dissimilarity (3.05) due to little intermingling of these butterflies due restraint on the part of Class "b" butterflies in this zone. Highest disparity (9.51) was observed when Classes "a" and "c" were paired followed by the pairing of "b" and "c" Classes (8.09).

India has around 1,501 species of butterflies, out of which 334 species have been reported from Western Ghats (Evans, 1932; Kunte, 2000) and 316 species have been reported from Kerala (Palot *et al.,* 2012). Mathew *et al.* (2004a, 2004b) and Shamsudeen and Mathew (2010) recorded 73 butterfly species in the non swampy areas of Shendurney Wildlife Sanctuary and 51 butterflies from nearby Peppara Wildlife Sanctuary. These studies also recorded that Nymphalidae had the maximum number of species which was similar to our results. Padhye *et al.* (2006) reports two peaks in the butterfly alpha diversity during summer and early winter which is similar to our observations of minimum species recorded in rainy (monsoon) season when compared to summer (pre-monsoon) and winter (post-monsoon) (Fig. 3).

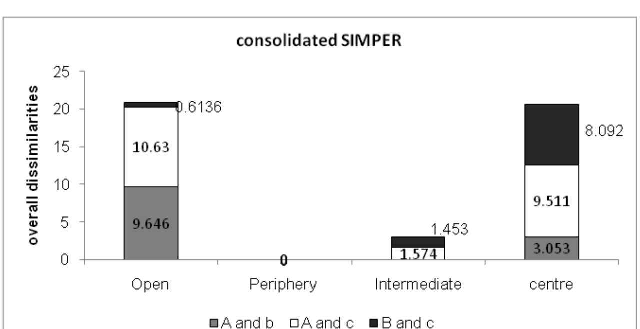

Fig.7 : Overall dissimilarities in different sampling zones

The *Myristica* swamp forests occupy lesser land area and were subjected to less intensive study yet it shows higher butterfly diversity. Generally, the presence of a large number of species in a small area is appreciated as "rich biodiversity" which may ignore various hidden implications. "Is this high diversity at the expense of habitat specialists and the proliferation of generalists?"

Table 3 : SIMPER (Similarity Percentage) showing the dissimilarities contributed by butterfly classes 'a', 'b' and 'c' in the different sampling zones

		Open	Periphery	Intermediate	Centre	
A and b	Contribution	9.646	0	0	3.053	
	Cumulative %	75.96	100	100	100	
	Overall average dissimilarities					12.7
A and c	Contribution	10.63	0	1.574	9.511	
	Cumulative %	48.96	100	100	92.75	
	Overall average dissimilarities					21.72
B and c	Contribution	0.6136	0	1.453	8.092	
	Cumulative %	100	100	93.96	79.66	
	Overall average dissimilarities					10.16

Declaration – I, Joyce Jose declare that the manuscript has not been published in any journal/book or proceedings or in any other publication or offered for publication elsewhere in substantially the same or abbreviated form, either in print or electronically.

Devy and Davidar (2001) has pointed out that logged forests harbour greater number of ubiquitous species but certain specialists like *Idea malabarica* may show restraint in such forests. Padhye (2006) has suggested that maximum diversity is seen in partially disturbed areas with human habitation

In the light of the 1. restraint shown by "a" class butterflies, 2. higher number of species in the forests outside the *Myristica* swamps and its immediate surroundings, 3. the preference towards the ectone and outside of the swamp shown by "b" class butterflies, It may be suggested that the preference for ecotone between the swamp forests and the adjacent matrix is due to :

1. Some species broadening their ecological amplitude to combat fragmentation.
2. The excessive humidity, lack of sunlight penetration, high area under inundation and low undergrowth in a *Myristica* swamp forest which may be a deterrent for many species. But its ecotone while retaining the characters of evergreen forests provides the habitat requirements absent in the swamp. The importance of the ecotone of the *Myristica* swamps has been suggested in a previous study concerning the Indian Kangaroo Lizard (Joyce *et al.,* 2007).

The values of various habitat variables show high similarity in Shendurney and Kulathupuzha. This similarity is especially marked in the intermediate and centre zones. Anchal on the other hand gives values (relatively higher temperature, lower humidity, lesser inundation and canopy cover, higher undergrowth as indicated by higher values of host plants and more litter) which indicate a progressive desiccation of the swamps. This may have caused the complete lack of "a" class butterflies inside the swamps of Anchal. In Shendurney there is a sudden decline in the host plants and litter cover in the periphery zone, which is attributed to the clearing of fire-lines along the boundaries of the swamp. This corresponds to a slight decline in the number of butterfly species present in the periphery. This decline was caused by the absence of some class "b" and "c" butterflies.

Henle *et al.* (2004) have suggested that shade-tolerant species are fragmentation sensitive because an increased mortality, lower growth rate, and lower dispersal capability compared to edge species lead to a competitive disadvantage under the modified light and increased disturbance regimes and have quoted many studies which suggest that forest fragmentation, especially edge effects, will favour medium-sized generalists and that common species have better dispersal power than less common sympatric species.

Other studies (Saikia, 2011; Saikia *et al.,* 2009) suggest that moisture availability, humidity, changes in canopy cover and light penetration through microclimatic effects have an impact on butterfly distributions and abundance and state that increasing diversity in degraded forest is associated with the loss of species with restricted geographical distribution.

Conclusions

Following conclusions may be drawn:

1. A classical *Myristica* swamp with dense canopy, negligible undergrowth, and perennial inundation do not provide habitat variables suitable for many butterflies, but high butterfly species richness was observed in and around the swamps when compared to some previous studies in the region.

2. This could be due to-

a. *Myristica* swamps are contiguous with the surrounding forests and have high species turnover for mobile organisms. The ecotone of swamp and adjoining habitat provide more microhabitat heterogeneity.

b. Increased ecological amplitude due to less vulnerability to environmental fluctuations of b and c class butterflies as an answer to fragmentation

3. Forest fragmentation, especially edge effects, favour common generalist species, while less than common sympatric specialist species become restricted.

4. The centre zone of the swamps having typical swamp characters hosted less butterfly species (only specialists) when compared to other zones, which had less swampy characteristics.

5. The swamps show characteristics of anthropogenically disturbed, fragmented environments *i.e.* a decrease in rare specialist species and increase in generalist species.

6. Species richness and species microhabitat utilization may mirror the cryptic changes in a specialised habitat.

We conclude that increase in the butterfly species diversity in the study area is not a result of a healthy and unfragmented habitat but may be the indicator of increase in microhabitats and host plants associated with disturbance which points to changes in the swamp environment. Ground truthing and previous studies (Rodgers and Panwar, 1988 a & b; Varghese, 2002; Roby and Nair, 2006; Roby, 2011, Joyce, 2010, Joyce *et al.*, 2014) already indicate these swamp forests as being fragmented and disturbed. While high species diversity is always something to cheer about, the expenditure of specialist species is a high cost to pay. Immediate measures to at least maintain status quo in the environmental gradients of the *Myristica* swamps in Southern Kerala if not Priority I level implementation of Myristica swamp Wildlife Sanctuary proposed by Rodgers and Panwar (1988 a & b) 27 years ago is suggested.

Acknowledgements

The work was part of a KFRI project funded by the Ministry of Environment and Forests, Govt' of India. We are grateful to Dr. J. K. Sharma, Dr. R. Gnanaharan and Dr. K. V. Sankaran (former Directors of KFRI) and the present Director of KFRI for encouragement and support. We acknowledge Dr. George Mathew and Dr. Raju Padavil for confirming species identifications; Mr. Shinoj T.M. and our trackers for assistance in field and the Kerala State Forest Department for co-operation.

दक्षिण पश्चिम घाट, भारत में *माइरिस्टिका* दलदल वनों की स्थिति – एक निर्देशक के रूप में तितली प्रजाति समृद्धता

जॉयसी जोस, टी.जे. रॉबी, के.के. रामाचन्द्रन एवं पी.वी. नायर

सारांश

दक्षिण–पश्चिम घाट, केरल, भारत में माइरिस्टिका दलदल वनों के अत्यधिक विखंडित, संकटस्थ एवं प्रतिबंधित खण्डों में तथा इसके चारों ओर तितलियों की प्रजाति समृद्धता प्रलेखित की गई। 1.5 वर्ग कि.मी. से कम भूमि क्षेत्रफल (149.75 हैक्टे.) के साथ इन दलदल वनों से 5 कुलों से संबधित तितलियों की अस्सी प्रजातियां अभिलिखित की गई। दलदलों के भीतर और बाहर प्रजाति संयोजनों ने 80 प्रतिशत से अधिक समानता को दर्शाया। तितली प्रजाति की उपस्थिति–अनुपस्थिति परपोषी पादप विविधता, छत्रावरण की प्रतिशतता, जलमग्न क्षेत्र की प्रतिशतता और भू खरपतवार आवरण की प्रतिशतता में विभिन्नता द्वारा प्रभावित होती है। आवास उपयोग अध्ययनों ने दर्शाया कि जबकि आवास विशेषज्ञ सदाहरित वनों के बड़े खण्डों तक सीमित थे, आवास सामान्यविद इसी तरह निरूद्ध नहीं थे तथा इसमें अधिकांश प्रजातियां थी। दलदलों एवं समीपवर्ती मैट्रिक्स के बीच इकोटोन क्षेत्र, उन क्षेत्रों को छोड़कर जहां इकोटोन विक्षुब्ध था, में अपेक्षाकृत प्रजातियों की संख्या ज्यादा थी। आवास विशेषज्ञों की कीमत पर तितली प्रजाति विविधता में वृद्धि और सामान्यों के प्रचुरोद्भवन दलदल पर्यावरण में रहस्यमय परिवर्तनों के एक सूचक हैं, जिसके फलस्वरूप विक्षोभ के साथ सम्बद्ध सूक्ष्म आवासों एवं परपोषी पादपों में वृद्धि होती है इसलिए तत्काल संरक्षण उपाय करने की जरूरत है।

References

Benedick S., Hill J.K., Mustaffa N., Chey V.K., Maryati M., Searle J.B., Schilthuizen M. and Hamer K.C. (2006). Impacts of rain forest fragmentation on butterflies in northern Borneo: species richness, turnover and the value of small fragments, *Journal of Applied Ecology,* 43: 967–977.

Champion H.G. and Seth S.K. (1968). *A revised survey of the forest types of India.* Government of India Press, xxiii+404 pp.

Chandran M.D.S. and Mesta D.K. (2005). *Myristica* swamps, Sahyadri E-news, Issue13.http//wgbis.ces.iisc.ernet.in/biodiversity/sahyadrienews/mewsletter/issue13/index.htm. Accessed on 23-01-07.

Chandran M.D.S., Mesta D.K. and Naik M.B. (1999). *Myristica* swamps of Uttara Kannada District, *My Forest,* 35(3): 217-222.

Devy S.M. and Davidar P. (2001). Response of wet forest butterflies to selective logging in Kalakad – Mundanthurai Tiger Reserve: Implications for Conservation, *Curr. Sci.*, 80: 400-405.

Evans W.H. (1932). *The identification of Indian butterflies*. 2nd edition. Bombay Natural History Society, Mumbai, India, 464 pp.

Ewers R.M. and Didham R.K. (2005). Confounding factors in the detection of species responses to habitat fragmentation, *Biol. Rev.*, 81: 117-142.

Gunathilagaraj K., Perumal T.N.A., Jayaram K. and Ganesh Kumar M. (1998). *Some South Indian Butterflies*. Nilgiri wildlife and Environment Association, Udhagamandalam, xv+273 pp.

Henle K., Davies K.F., Kleyer M., Margules C. and Settele J. (2004). Predictors of species sensitivity to fragmentation, *Biodiversity and Conservation,* 13: 207–251.

Joyce J. (2010). Animal Diversity of *Myristica* swamps in Southern Kerala with emphasis on Herpetofauna, Ph. D. thesis, FRIU Dehradun: 134+xviii pp.

Joyce J., Ramachandran K.K. and Nair,P.V. (2007). A rare and little known lizard, *Otocryptis beddomii*, from the *Myristica* swamps of Southern Kerala, India, *Herpetological Bulletin*, 101: 27-31.

Joyce J., Roby T.J., Ramachandran K.K. and Nair P.V. (2014). Species abundance distribution of selected communities in the *Myristica* swamp forest of southern Kerala, *Current Science*, 107(3): 447-453.

Kehimkar I. (2008). *The Book of Indian Butterflies*. BNHS. Oxford University Press, xvi+497 pp.

Kocher S.D. and William E.H. (2000). The diversity and abundance of North American butterflies vary with habitat disturbances and geography, *Journal of Biogeography*, 27: 785-794.

Kremen C. (1992). Assessing the indicator properties of species assemblages for natural areas monitoring, *Ecological Applications*, 2: 203-217.

Krishnamoorthy K. (1960). *Myristica* swamps in the evergreen forests of Tranvancore, *Indian. Forester*, 86(5): 314-315.

Kunte K. (2000). *Butterflies of Peninsular India*. Project Lifescape. Indian Academy of Sciences, Universities Press, Hyderabad, India, xviii+254 pp.

Mathew G., Chandran R., Brijesh C.M. and Shamsudeen R.S.M. (2004a). Insect fauna of Shendureney Wildlife Sanctuary, Kerala. *Zoos' Print*, 19(1): 1321-1327.

Mathew G., Shamsudeen R.S.M., Chandran R. and Brijesh C.M. (2004b). Insect fauna of Peppara Wildlife Sanctuary, Kerala, India. *Zoos' Print*, 19(11): 1680-1683.

Nair P.V., Ramachandran K.K., Swarupanandan K. and Thomas T.P. (2007). *Mapping biodiversity of the Myristica swamps in southern Kerala*. Kerala Forest Research Institute, Research Report No. 326, 255pp.

Ockingera E., Hammarstedtb O., Nilssona S.G. and Smith H.G. (2006). The relationship between local extinctions of grassland butterflies and increased soil nitrogen levels, *Biol. Conserv.*, 128: 564-573.

Padhye A.D., Dahanukar N., Paingankar M., Deshpande M. and Deshpande D. (2006). Season and Landscape wise distribution of Butterflies in Tamhini, Northern Western Ghats, India. *Zoos' Print Journal,* 21(3): 2175-2181.

Palot J.M., Balakrishnan V.C. and Kambrath B. (2003). *Keralathile Chithrashalabhangal (Butterflies of Kerala)*. Malabar Natural History Society, Kozhikode, 195 pp.

Palot M.J., Balakrishnan V.C. and Kalesh S. (2012).An updated check list of butterflies of Kerala, with their Malayalam names, *Malabar Trogon*, 9(3): 22-29.

Pascal J.P. (1988). *Wet evergreen forests of the Western Ghats of India.* French Institute, Pondichery. 345 pp.

Pollard E. (1991). Monitoring butterfly numbers. In: *Ecology* (F. B. GoldSmith ed.). Chapmann and Hall, London, 87-111 pp.

Ramesh B.R. and Pascal J.P. (1997). *Atlas of the endemics of the Western Ghats (India*). *Distribution of tree species in the evergreen and semi-evergreen forests*. French Institute, Pondicherry, 403 pp.

Roby T.J. (2011). *Floristic structure and diversity of Myristica Swamps at Kulathupuzha in a GIS perspective*. Ph. D. thesis, FRIU, Dehradun: 148+xxxi pp.

Roby T.J. and Nair P.V. (2006). *Myristica* swamps – an endangered ecosystem in the Western Ghats. In: *The Proceedings of the XVIII Kerala Science Congress*, 29-31January 2006, 386 –388. Centre for Earth Science Studies, Thiruvananthapuram (Kerala)

Roby T.J., Nair P.V. and Joyce J. (2014a). GIS techniques for Mapping highly Fragmented ecosystems- A case study on the *Myristica* swamp forests of Southern Kerala, India, *Research Journal of Recent Sciences*, 3(ISC-2013): 110-119.

Roby T.J., Joyce J. and Nair P.V. (2014b). Checklist of Flora of *Myristica* Swamps – A Critically Endangered Fresh Water Ecosystem of Southern Western Ghats of Kerala, India, *Indian Forester*, 140(6): 608-616.

Rodgers W.A. and Panwar H.S. (1988a). *Planning wildlife protected area network in India*. Vol I. The Report. A report prepared for the Department of Environment, Forests and Wildlife, Government of India at Wildlife Institute of India, 341 pp.

Rodgers W.A. and Panwar H.S. (1988b). *Planning wildlife protected area network in India*. Vol II. State Summaries. A report prepared for the Department of Environment, Forests and Wildlife, Government of India at Wildlife Institute of India, 267 pp.

Rossi J.P. and van Halder I. (2010). Towards indicators of butterfly biodiversity based on a multiscale landscape description, *Ecological Indicators*, 10: 452–458.

Saikia K.M. (2011). Impact of tropical forest degradation on nymphalid butterflies: A case study in Chandubi tropical forest, Assam, India, *Int. J. Biodvers. Conserv.* 3(12): 650-669

Saikia K.M., Kalita J. and Saikia P.K. (2009). Ecology and conservation needs of nymphalid butterflies in disturbed tropical forest of Eastern Himalayan biodiversity hotspot, Assam, India, *Int. J. Biodvers. Conserv.* 1(7): 231-250.

Santhakumaran L.N., Singh A. and Thomas V.T. (1995). Description of a sacred grove in Goa (India), with notes on the unusual aerial roots produced by its vegetation, *Wood,* Oct-Dec: 24-28.

Shamsudeen R.S.M. and Mathew G. (2010).Diversity of butterflies in Shendureny Wild life Sanctuary, Kerala, *World Journal of Zoology*, 5(4): 324-329.

Varghese V. (1992). *Vegetation Structure, floristic diversity and edaphic attributes of the fresh water swamps forests in Southern Kerala*. B.Sc. degree dissertation, College of forestry, Kerala Agricultural University, Mannuthy:113+iv pp.

Varghese A.V. and Kumar B.M. (1997). Ecological observations in the fresh water swamp forests of Southern Kerala, India, *J. Trop. Forest Sci.,* 9: 299-314.

Varghese A.O. and Menon A.R.R. (1999). Floristic composition, dynamics and diversity of *Myristica* swamp forests of southern Western Ghats, Kerala, *Indian Forester*, 125: 775-783.